U.S. Fish and Wildlife Service

Region 2

Contaminants Program

CONTAMINANTS IN PREY OF BALD EAGLES NESTING IN ARIZONA

by

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ABSTRACT--Fish collected near eight bald eagle (*Haliaeetus leucocephalus*) nesting territories in Arizona from April to July 1988 contained low levels of organochlorine compounds and most trace metals. Chlordane and DDE were the organochlorines detected most frequently. The maximum concentration of chlordane, 0.03 $\mu g/g$ wet weight, was below the National Contaminant Biomonitoring Program (NCBP) geometric mean of 0.11 $\mu g/g$. The maximum DDE concentration of 0.23 $\mu g/g$ was similar to the NCBP geometric mean of 0.19 $\mu g/g$.

Mercury and copper were recovered at elevated levels more frequently than other trace elements. Both were present in 45 percent (%) of the samples at, or above, the NCBP 85th percentile. Mercury was detected in all samples and individual concentrations ranged to 0.97 $\mu g/g$. All fish samples from Alamo Lake, Verde River Cliff, Salt River, and Tonto Creek exceeded 0.1 $\mu g/g$; the concentration above which mercury effects on fish-eating avian predators can be expected. One fish sample contained 0.97 $\mu g/g$ mercury which approached the maximum allowable level for human consumption. Mercury concentrations in bald eagle eggs collected in Arizona between 1977 and 1985 were above levels reported for most other North American eagle populations and may reflect elevated mercury in the resident fish prey base. With the exception of mercury, concentrations of environmental contaminants were below levels usually associated with acute or reproductive effects on birds.

Elevated levels of some trace elements, however, is cause for concern for the welfare of some of Arizona's endangered fish species. Eighty-three percent of the fish samples had elevated levels of one or more trace elements; 52% had elevated levels of at least two trace elements.

Because some trace elements approached potentially harmful concentrations, we recommend continued sampling of eagle prey items at all sites on a 3-year basis. Emphasis should be placed on collecting preferred prey species. Sampling should be continued until all contaminant concentrations remain below the level of concern for at least two consecutive sampling periods. Because mercury was particularly high in fish collected from 5 of 8 sites, we recommend that unhatched eagle eggs from these areas be analyzed for mercury.

INTRODUCTION

Bald eagle (*Haliaeetus leucocephalus*) populations declined throughout most of the United States due primarily to former widespread use of organochlorine pesticides (Krantz et al. 1970; Wiemeyer et al. 1972, 1984; Grier 1974, 1982). Localized declines of eagles and other fish-eating raptors were associated with either pesticide-induced eggshell thinning or direct mortality from pesticide poisoning (Anderson and Hickey 1972; Wiemeyer et al. 1984). During the 1980s, many bald eagle populations exhibited partial recovery following cancellation or restriction of organochlorine pesticide use. In Arizona, the known bald eagle breeding population has increased in recent years but, reproductive success at certain nests has been inconsistent.

Liile is known about contaminant levels in bald eagle prey items or their potential effects on recruitment. This report documents organochlorine and trace element concentrations in selected fish prey of bald eagles nesting in Arizona and discusses implications of current levels on reproductive success.

MATERIALS AND METHODS

Fish were sampled near each of eight eagle breeding territories from April to July 1988 (Fig. 1). Samples were collected following the eagles hatching cycle to minimize disturbance near the nest site during the sensitive incubation period. Collections focused on preferred eagle prey items such as channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), Sonora sucker (*Catostomus insignis*) and desert sucker (C. *clarki*) (Haywood and Ohmart 1986). Other species including largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), and white bass (*Morone chrysops*) were substituted when we were unable to collect the preferred prey items. All samples were collected by electroshocking, net (gill, trammel or seine), or hook and line. Samples were pooled in five-specimen composites of near equal length and weight for each species. Fish were weighed and measured following collection, wrapped in aluminum foil and chilled on wet ice. Samples were later transferred to a commercial freezer and stored frozen until chemical analyses.

Chemical analyses were completed at the Patuxent Wildlife Research Center, Laurel, Maryland. Samples were analyzed for p,p'-DDE, p,p'-DDD, p,p'-DDT, dieldrin, heptachlor epoxide, hexachlorobenzene (HCB), oxychlordane, cis-chlordane, *trans*-nonachlor, cis-nonachlor, endrin, toxaphene, mirex and polychlorinated biphenyl (PCB). Chlordane residues reported here are the sum of individual components (*cis*-chlordane, *trans*-nonachlor, and *cis*-nonachlor). For each organochlorine analysis, the sample was homogenized and a portion mixed with anhydrous sodium sulfate and extracted with hexane in a Soxhlet apparatus for 7 hours. Lipids were removed by Florisil column chromatography (Cromartie et al. 1975). Sep-pak Florisil cartridges were used for removal of lipids (Clark et al. 1983). The organochlorine compounds were separated into four fractions on a SilicAR column (rather than three fractions) to ensure the separation of dieldrin or endrin into an individual fraction (Kaiser et al. 1980). The individual fractions were analyzed with a gas-liquid chromatograph equipped with an electron-capture detector and a 1.5/1.95% SP-2250/SP-2401 column. Residues in 10% of the samples were confirmed by gas chromatography/mass spectrometry. The lower limit of quantification was 0.1 μg/g for all organochlorine pesticides and 0.5 μg/g for PCB. Because high levels of DDE were recently detected in some Arizona wildlife (Kepner 1987), a special effort was made to assess the levels of dicofol in fish samples. The principal commercial dicofol product (Kelthane) contained as much as 15% DDT family compounds (DDT, DDD, DDE and chloro-DDT) in 1982 (Clark 1990). The lower limit of quantification was 0.1 μg/g wet weight for all organochlorine insecticides, PCB, and dicofol.

Samples were also analyzed for selected trace elements including aluminum, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, thallium, and zinc at the Environmental Trace Substances Research Center, Columbia, Missouri. Arsenic and selenium were analyzed by atomic absorption hydride and mercury by cold vapor reduction. All other trace elements were analyzed by inductively coupled plasma atomic emission spectroscopy. Organochlorine and trace element residues are reported on a wet weight basis with percent moisture listed for each sample to facilitate wet weight to dry weight conversions (Table 1). To convert wet weight values to dry weight equivalents, divide the wet weight values by 1 minus the percent moisture.

RESULTS AND DISCUSSION

Reproductive success--Productivity of bald eagles nesting in Arizona averaged 0.80 young per occupied territory from 1975 to 1981 (Forbis 1988) and 1.13 from 1982 to 1986 (Grubb et al. 1990). During 1988, when eagle prey items were collected, 4 of 27 known territories were inactive, 3 were occupied but no eggs were laid, 4 nests contained eggs that did not hatch or young that died before fledging, the fate of one nest was unknown, and 15 nests fledged 24 young (Biosystems Analysis, Inc. 1991). Therefore, overall productivity in 1988 was 1.04 (24 young/23 occupied nests) (Table 1).

To maintain a stable population, at least 50% of nesting bald eagle pairs must be successful and produce a minimum of 0.7 young/occupied nest (Sprunt et al. 1973). A slightly higher reproductive rate of 1.0 young/occupied nest is indicative of a 'healthy' population (Wiemeyer et al. 1984). During the two decades from 1970-1990, productivity averaged 0.93 and was considered relatively stable (BioSystems Analysis, Inc. 1991). However, the eagle fledging rate in Arizona has been biased upwards since 1985 due to efforts of individuals associated with the Southwestern Bald Eagle Management Committee who have 'rescued' nestling eagles from fish line entanglement, fish hooks and inadvertent human disturbance. Mortality also may have been biased by radiotelemetry of nestlings. While annual productivity figures are useful indicators of population stability, they should be interpreted with caution; more accurate indicators of environmental quality are trends in reproductive success over a period of several years.

Oraanochlorine concentrations--Chlordane and DDE were the organochlorines detected most frequently in fish samples (Table 2). Chlordane concentrations ranged from below detectable levels to 0.03 $\mu g/g$ and chlordane was recovered most consistently in fish from the Verde River Ladders site. The maximum concentration, 0.03 $\mu g/g$, was well below the National Contaminant Biomonitoring Program (NCBP) geometric mean (0.11 $\mu g/g$) for total chlordane in whole body fish collected from 112 stations throughout continental United States in 1984 (Schmitt et al. 1990).

DDE was detected in all samples and individual levels ranged from 0.01 to 0.23 $\mu g/g$ (mean = 0.07 $\mu g/g$). The maximum concentration, 0.23 $\mu g/g$, was similar to the national geometric mean (background level) of 0.19 $\mu g/g$ as established by the NCBP (Schmitt et al. 1990). Dieldrin, the only other insecticide detected, was recorded at 0.01 $\mu g/g$ in three samples. Dicofol was not recovered in any fish. PCBs were present at low (10.07 $\mu g/g$) levels in only two samples. The variation in fish species sampled at each site and the generally small sample size (maximum 2 samples per species per site) precluded statistical tests to determine residue differences among sites and among species.

Trace element concentrations--Aluminum was detected in all 29 samples and concentrations ranged from 1.7 $\mu g/g$ in largemouth bass from Alamo Lake to 694.5 $\mu g/g$ in desert sucker from the Verde River Ladders site (Table 3). Highest aluminum levels were present in the desert sucker, channel catfish (219.0 $\mu g/g$), and Sonora sucker (110.5 $\mu g/g$) from the Verde River Ladders site; all these fish were preferred eagle prey items. Goldfish from San Carlos Reservoir also contained high levels of aluminum. No comparable data are available to assess whether aluminum concentrations found in this study are elevated or within the normal background range.

Arsenic was recovered in 86% (25/29) of the samples. Concentrations ranged from not detected to 1.06 µg/g. The NCBP 85th percentile for arsenic was 0.27 µg/g (Schmitt and Brumbaugh 1990). The 85th percentile is an arbitrary figure considered as a level significantly higher than background concentrations. Elevated arsenic residues (≥ NCBP 85th percentile) occurred most frequently in fish from Lake Pleasant; the mean level was 0.36 µg/g. Three samples from Lake Pleasant and one each from Verde River Ladders, Verde River Cliff, San Carlos Reservoir and Roosevelt Lake exceeded the NCBP 85th percentile. Other reports suggest that arsenic whole body levels above 0.5 µg/g are harmful to predators (Walsh et al. 1977). Two samples of bald eagle preferred prey, channel catfish from Lake Pleasant (0.78 µ/g) and desert sucker from Verde River Ladders (1.06 µg/g), exceeded this concern level.

Cadmium was detected in 21 of 29 fish samples. Highest mean concentrations occurred in fish from the Verde River Ladders and Cliff areas (both = 0.06 µg/g). Cadmium exceeded the NCBP 85th percentile of 0.05 µg/g in 6 samples, all were preferred eagle prey species (Table 3). The highest individual cadmium concentration was 0.12 µg/g; none of the fish contained cadmium concentrations approaching the 0.5 µg/g level considered harmful to fish and wildlife (Walsh et al. 1977).

Lead was detected in three Alamo Lake samples at 0.10, 0.13 and 0.21 µg/g and in two Verde River fish at 0.13 and 0.67 µg/g. Beryllium was recovered in one sample from Alamo Lake and one sample from San Carlos Reservoir at 0.01 µg/g, and in two Verde River fish at 0.01 and 0.02 µg/g. Thallium was not detected in any samples.

Copper and mercury were recovered at elevated levels more frequently than other trace elements. Both were present in 45% (13/29) of the samples at, or above, the NCBP 85th percentile level. A single sample of carp from Alamo Lake had an extremely elevated copper level of 41.60 µg/g; about 5 times greater than the next highest residue and about twice that of the highest copper concentration detected during the 1976-1984 NCBP (Schmitt and Brumbaugh 1990). The next most heavily contaminated areas were Lake Pleasant, Verde River Ladders and San Carlos Reservoir.

Mercury was present in all samples and individual concentrations ranged from 0.06 to 0.97 µg/g. Highest mean levels were recovered in fish from Lake Pleasant (0.41 µg/g), Salt River (0.21 µg/g) and Alamo Lake (0.19 µg/g); all were above the NCBP 85th percentile of 0.17 μg/g. The maximum concentration above which effects on fish-eating avian predators can be expected is 0.1 μg/g (Eisler 1987). All individual fish samples from Alamo Lake, Verde River Cliff, Salt River, and Tonto Creek exceeded this 0.1 μg/g concern level. Mercury concentrations in bald eagle eggs collected in Arizona between 1977 and 1985 were above background levels for most North American bald eagle populations (Grubb et al. 1990) and may reflect elevated mercury in the resident fish prey base.

Chromium, iron and manganese were present in all samples and levels varied from 0.03-I .80, 16.5-706.6 and 0.50-23.74 μg/g, respectively. Background levels for these trace elements in fish and the propensity for their bioaccumulation through the aquatic food chain to avian predators are not well known.

Nickel was recovered in all but two samples. There are no national standards to determine at what level nickel is toxic to avian predators and the potential for bioaccumulation of nickel also is not well understood. Mean levels were greatest in fish from Verde River Ladders (0.59 μg/g) and Lake Pleasant (0.51 μg/g) sites. The highest individual nickel residue was detected in the desert sucker sample from Verde River Ladders, 1.62 μg/g.

Selenium was present at elevated ($\geq$ 0.73 μg/g, NCBP 85th percentile) concentrations in 5 of 29 samples. The background level of selenium in aquatic food chain organisms is usually $\leq$ 2.0 μg/g dry weight (appx. 0.4 μg/g converted to wet weight) (Ohlendorf et al. 1989). At Kesterson National Wildlife Refuge, California where reproduction of several bird species was adversely affected by high selenium levels in the diet, most aquatic food chain items generally contained about 10 μg/g selenium (converted to wet weight) (Ohlendorf et al. 1989). None of the fish in our sample approached the hazardous level found in food chain organisms at Kesterson.

Zinc was recovered at elevated ($\geq$ 32.4 μg/g, NCBP 85th percentile level) concentrations in 28% (8/29) of the samples. Alamo Lake had the greatest mean zinc level of 38.7 μg/g and the highest individual concentration was 97.53 μg/g in carp from Alamo Lake. Little is known about bioaccumulation of zinc through the aquatic food chain to predators such as fish-eating birds.

<u>Residue implications for fish</u>--It is difficult to assess residue levels among fish species when many species were collected at only one location. However, the following generalizations can be made regarding contaminant levels in individual fish species. White bass, taken at Lake Pleasant only, appear to be highly contaminated with mercury, arsenic, selenium and copper. Mercury was higher in

white bass than in all other species and concentrations were almost 4 to 6 times greater than the concern level established by the NCBP. In one sample, mercury concentrations of 0.97 $\mu g/g$ approached the maximum allowable level for human consumption of 1 .O $\mu g/g$ (Pastorok 1987). Copper in Lake Pleasant white bass was about 4 to 8 times greater than the NCBP 85th percentile and both samples also contained elevated arsenic and selenium.

Largemouth bass, collected from 5 of 8 sites, had elevated mercury levels at Lake Pleasant, Alamo Lake, and San Carlos Reservoir. The single most contaminated sample was taken from San Carlos Reservoir and contained mercury, arsenic and selenium in excess of the NCBP 85th percentile. Excessive copper was also detected in one bass sample from Lake Pleasant.

Channel catfish and carp, both preferred eagle prey species, were collected at 6 of 8 sites. Catfish from Alamo Lake, San Carlos Reservoir and Salt River contained elevated concentrations of mercury. Arsenic was high only in channel catfish from Lake Pleasant. Catfish from the Verde River had elevated cadmium and copper concentrations and those from San Carlos Reservoir had elevated copper.

Carp accumulated zinc more readily than other species; every sample $(n=7)$ contained zinc in excess of the NCBP 85th percentile. This finding is consistent with those of other authors who reported that the common carp apparently accumulate zinc to a greater extent than other species (Lowe et al. 1985, Schmitt and Brumbaugh 1990). Carp were also efficient bioaccumulators of copper, acquiring high ($\geq$ 1 .O $\mu g/g$, NCBP 85th percentile) concentrations at all six collection locations.

The desert sucker and Sonora sucker, also preferred eagle prey species, were collected only at Verde River Ladders. Desert sucker accumulated high levels of arsenic, cadmium, and copper. In contrast, Sonora sucker from the same area did not bioaccumulate any trace elements to potentially harmful levels.

Four fish species (goldfish, black crappie, flathead catfish and yellow bullhead) were collected at only one location therefore, generalizations about accumulation rates in these species would be speculative.

Elevated levels of some trace elements is cause for concern for the welfare of some of Arizona's endangered fish species. Eighty-three percent of the fish samples had elevated levels of one or more trace elements; 52% had elevated levels of at least two to four trace elements.

Residue implications for the bald eagle--DDE, at levels recovered in this study (mean = 0.07, maximum = 0.23 $\mu g/g$) should not have a significant impact on eagle reproduction, at least as far as eggshell thinning is concerned. DDE concentrations in Arizona bald eagle prey items were lower than those from Maine, Oregon and Wisconsin (Wiemeyer et al. 1978, Frenzel 1984, Kozie and Anderson 1991). DDE levels found in this study are also lower than the 0.5 $\mu g/g$ level that represents the lower limit of concern for eggshell thinning in bald eagles (U. S. Fish and Wildlife Service 1986). These data should be interpreted with caution as most eagles are migratory and assessing levels of contaminants in food only at nesting territories can be misleading as highly lipotrophic organochlorines acquired on the wintering areas may mask the effects of contaminants acquired locally.

The trace elements most likely to cause reproductive problems in birds are arsenic, cadmium, mercury and selenium. When considering only the eagle's preferred prey species (common carp, channel catfish, desert sucker and Sonora sucker) the areas and elements most likely to cause problems are: Lake Pleasant- arsenic, Alamo Lake- mercury and cadmium, Verde River Ladders and Cliff- cadmium and selenium, San Carlos Reservoir- mercury and cadmium, Salt River- mercury, Tonto Creek- mercury. The area that seemed most consistently contaminated by mercury was Alamo Lake; all five collections were close to the NCBP 85th percentile. Also, the Salt River may be mercury contaminated as the two samples collected there were over the NCBP 85th percentile.

RECOMMENDATIONS

Because some trace element levels approached potentially harmful concentrations, we recommend continued sampling of eagle prey items at all sites on a 3-year basis. Emphasis should be placed on sampling preferred prey species, especially catfish and carp which together comprised 87% of the fish prey items (Haywood and Ohmart 1986). Some sites included in this report were not thoroughly sampled, i.e. Salt River and Tonto Creek, and emphasis should be placed on collecting a comparable sample at all sites. We also recommend that sampling be continued until all contaminant concentrations remain below the level of concern for at least two consecutive sampling periods. Because mercury concentrations were particularly high in fish collected from Lake Pleasant, Alamo Lake, Salt River, Verde River (Cliff site), and Tonto Creek, we recommend that unhatched bald eagle eggs from these areas be analyzed for mercury.

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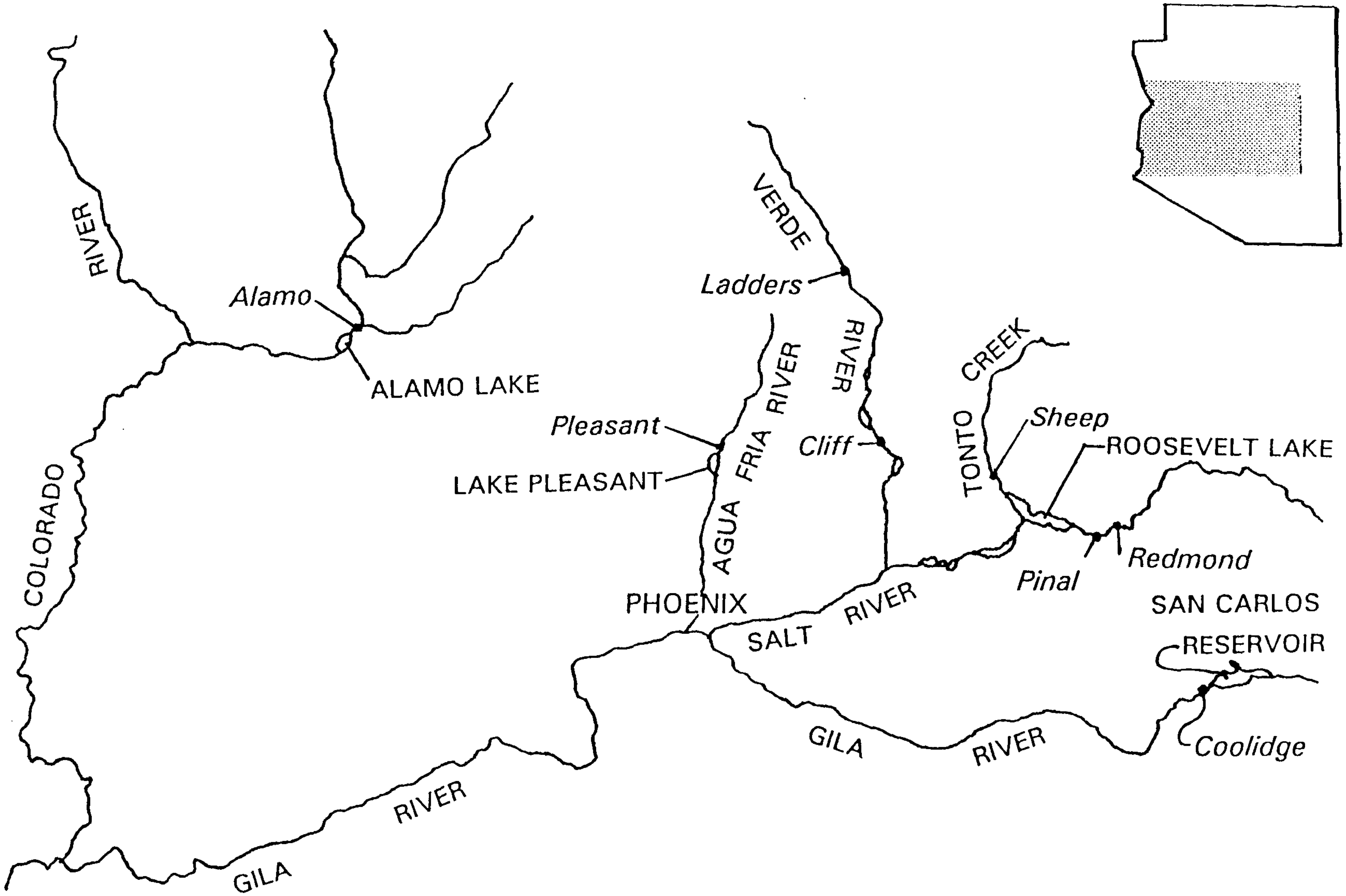

Figure 1. Location of bald eagle nesting sites and prey sampling locations in Arizona, 1988.

TABLE 1. Bald eagle reproduction at selected Arizona sites 1979-1988[1].

Sampling site & nest name	No. of[2] attempts	Successful[3] No.	(%)	Total Young	Young fledged per nesting attempt
Lake Pleasant					
Pleasant	3	0	(0)	0	0
Alamo Lake					
Alamo	1	1	(100)	1	1
Verde River				4	
Cliff	4	2	(50)	12	1
Ladders[4]	9	6	(67)		1.3
San Carlos Res.					
Coolidge	4	3	(75)	5	1.2
Roosevelt Lake					
Pinal[4]	8	6	(75)	8	1
Salt River					
Redmond	10	8	(80)	13	1.3
Tonto Creek					
Sheep	4	0	(0)	0	0

[1]Data from BioSystems Analysis, Inc. (1991).

[2]Includes active nests with one or more eggs.

[3]Defined as nests that fledged one or more young.

[4]Foster nests not included.

TABLE 2. Body measurements and organochlorine concentrations ($\mu g/g$ wet) of whole fish collected near active bald eagle eyriee in Arizona, 1988.

Area & species	N[1]	Percent moisture	Length mean±SD	Weight mean±SD	Chlor.	DDE
Lake Pleasant[2]						
Channel catfish	5	0.739	323±12	273±47	0.03	0.08
Largemouth base	5	0.754	306±7	359±12	ND[3]	0.07
Largemouth bass	5	0.748	296±9	307±17	ND	0.05
Common carp	5	0.787	332±5	500±12	ND	0.04
White bass	5	0.723	392±11	796±24	0.03	0.23
White bass	5	0.784	396±3	735±20	ND	0.13
Alamo Lake[4]						
Channel catfish	5	0.791	378±21	330±68	0.02	0.06
Channel catfish	5	0.801	321±35	238±77	ND	0.06
Largemouth baes	5	0.787	300±8	349±27	0.02	0.04
Common carp	5	0.751	499±25	1284±112	0.02	0.14
Common carp	5	0.699	458±10	1013±28	0.03	0.12
Verde River Ldr.						
Channel catfish	5	0.742	304±52	257±119	0.02	0.03
Desert sucker	5	0.758	290±51	298±139	0.02	0.02
Sonora sucker	5	0.730	410±11	736±30	0.03	0.04
Sonora sucker	5	0.723	353±36	544±167	0.03	0.03
Common carp	5	0.785	537±122	1853±588	0.02	0.05
Verde River Clf.						
Largemouth bass	2	0.726	272±11	298±54	0.03	0.02
Common carp	2	0.742	366±9	635±33	0.03	0.09
San Carlos Res.[4]						
Channel catfish	5	0.718	415±47	734±273	0.02	0.18
Largemouth bass	5	0.737	339±31	538±175	ND	0.16
Common carp	5	0.731	317±13	369±66	0.02	0.14
Goldfish	5	0.686	265±19	342±87	0.01	0.08
Roosevelt Lake[4]						
Channel catfish	5	0.754	362±13	371±46	0.03	0.04
Largemouth base	5	0.768	279±11	297±33	ND	0.03
Black crappie	5	0.749	254±11	241±29	ND	0.02
Common carp	5	0.757	427±13	940±82	ND	0.04
Salt River						
Channel catfish	5	0.793	359±29	383±97	ND	0.01
Flathead catfish	3	0.784	355±20	514±72	ND	0.02
Tonto Creek						
Yellow bullhead	4	0.789	212±46	174±121	ND	0.02

[1]Number of fish in each composite sample.

[2]PCBs were detected in one largemouth bass and one yellow bass from Lake Pleasant at 0.05 and 0.07 $\mu g/g$, respectively.

[3]ND = No residue detected.

[4]Dieldrin was detected at 0.01 $\mu g/g$ in one carp from Alamo Lake, in one goldfish from San Carlos Reservoir, and in one channel catfish from Roosevelt Lake.

TABLE 3. Trace element concentrations (µg/g wet weight) in bald eagle prey items from waters near active eyries in Arizona, 1988.

Area & species	Al	As	Cd	Cu	Cr	Fe	Hg	Mn	Ni	Se	Zn
NCBP 85 Percent'	NA²	0.27	0.05	1.0	WA	NA	0.17	NA	NA	0.73	34.2
Lake Pleasant											
Chew-catfish	68.4	0.78	0.03	0.60	0.50	102.6	0.09	5.79	0.37	0.44	16.68
Largemouth bass	3.7	0.23	ND'	0.79	0.17	24.8	0.37	1.91	0.13	0.66	15.10
Largemouth bass	3.8	0.25	ND	2.95	0.08	18.8	0.33	2.27	0.10	0.66	14.94
Common carp	2.8	0.23	0.03	1.41	0.03	19.2	0.06	1.65	0.14	0.36	52.61
Uhite bass	5.0	0.36	ND	8.12	0.12	25.5	0.66	1.58	0.11	1.27	14.04
Uhite bass	5.4	0.30	ND	3.93	0.12	29.2	0.97	1.21	0.06	0.99	13.59
Alamo Lake'			ND								
Channel catfish	29.1	ND	0.01	0.68	0.10	54.1	0.25	0.50	0.08	0.29	15.57
Channel catfish	48.2	ND	--	0.40	0.20	81.0	0.16	5.33	0.18	0.30	14.03
Largemouth bass	1.7	0.19	ND	0.34	0.04	16.5	0.20	1.47	0.06	0.43	11.76
Common carp	60.5	0.10	0.12	41.60	0.37	148.4	0.15	5.20	0.25	0.50	54.78
Comson carp	8.7	0.06	0.02	1.34	0.27	70.4	0.20	3.28	0.17	0.45	97.52
Verde River Ldr.³											
Channel catfish	219.0	0.24	0.09	1.74	0.44	163.3	0.04	8.90	0.39	0.59	20.18
Desert sucker	694.5	1.06	0.09	5.93	1.80	706.6	0.05	23.74	1.62	0.46	17.64
Sonora sucker	76.4	0.18	0.03	0.94	0.46	114.2	0.11	7.07	0.46	0.59	15.63
Sonora sucker	110.5	0.25	0.03	0.99	0.36	125.8	0.07	8.64	0.30	0.61	15.46
Common carp	15.5	0.10	0.04	1.39	0.24	49.0	0.18	1.69	0.16	1.01	43.64
Verde River Clf.³											
Largemouth bass	86.3	0.27	0.04	0.88	0.41	78.9	0.11	8.91	0.23	0.21	14.47
Common carp	60.6	0.26	0.09	1.49	0.15	81.8	0.12	2.94	0.13	0.87	40.25
San Carlos Res.³											
Channel catfish	15.8	0.08	0.01	1.61	0.22	39.2	0.21	2.07	0.15	0.54	18.56
Largemouth bass	3.4	0.50	ND	0.45	0.21	19.1	0.21	1.05	0.11	0.74	12.31
Common carp	39.0	0.25	0.12	1.09	0.30	109.7	0.08	2.93	0.11	0.56	54.61
Goldfish	221.4	0.24	0.07	1.75	0.88	351.7	0.04	8.95	0.50	0.50	45.53
Roosevelt Lake											
Channel catfish	29.3	0.07	0.04	0.94	0.37	39.6	0.08	20.12	0.23	0.23	13.21
Largemouth bass	7.2	0.12	0.01	0.55	0.10	20.1	0.10	1.58	ND	0.28	12.08
Black crappie	13.2	0.28	ND	0.25	0.22	22.1	0.07	4.37	0.08	0.25	13.83
Common carp	4.9	0.07	0.07	1.34	0.09	32.3	0.08	2.45	ND	0.36	53.22
Salt River											
Channel catfish	17.2	ND	0.02	0.52	0.09	26.1	0.21	2.15	0.11	0.35	13.99
Flathead catfish	9.8	ND	0.02	0.26	0.15	20.1	0.20	0.76	0.06	0.35	11.90
Tonto Creek											
Yellow bullhead	7.9	NO	0.01	0.50	0.06	41.1	0.18	1.39	0.08	0.32	15.23

'National Contaminant Biomonitoring Program 85th percentile (see Schmitt and Brumbaugh 1990).

²NA = Data not available. ND= No residue detected.

'Lead was detected in three Alamo Lake samples at 0.10, 0.13 and 0.21 µg/g and in tuo Verde River fish at 0.13 and 0.67 µg/g. Beryllium was recovered in one sample from Alamo Lake and one sample from San Carlos Reservoir at 0.01 µg/g, and in two Verde River fish at 0.01 and 0.02 µg/g. Thalliun was not detected in any samples.